CLAIMS

What is claimed is:

1. A method for generating a biotextile material comprising:
   (a) obtaining a biopolymer composition comprising a purified, recombinantly expressed protein, the recombinantly expressed protein having been expressed from a DNA coding sequence of a source protein, the DNA coding sequence having been optionally modified to include at least one tag sequence that enhances the crosslinking capacity of the recombinantly expressed protein;
   (b) exposing the composition to an enzyme to enzymatically crosslink the recombinantly expressed protein to at least another unit of the recombinantly expressed protein or another constituent of the biopolymer composition; and
   (c) generating a biotextile material based on the crosslinked composition, the biotextile material exhibiting a functional characteristic associated with the recombinantly expressed protein.

2. The method according to claim 1, wherein the biotextile material generated in (c) includes a plurality of fibers formed from the crosslinked composition, and the tag sequence added to the modified DNA coding sequence for the recombinantly expressed protein in (a) enhances fiber formation in (c).

   wherein the biotextile material generated in (c) includes a plurality of films formed from the crosslinked composition, and the tag sequence added to the modified DNA coding sequence for the recombinantly expressed protein in (a) enhances film formation in (c).

   ~~3.The method according to claim 1, wherein the biotextile material generated in (c) includes a plurality of films formed from the crosslinked composition, and the tag sequence added to the modified DNA coding sequence for the recombinantly expressed protein in (a) enhances film formation in (c).~~

~~4.~~3. The method according to claim 1, wherein the source protein is a fluorescent protein, and the recombinantly expressed protein has at least a fluorescence property of the source

protein, optionally wherein the source protein is a green fluorescent protein (GFP), a red fluorescent protein (RFP), a near-infrared fluorescent protein, or a blue fluorescent protein (BFP) .

~~5.The method according to claim 4, wherein the source protein is a green fluorescent protein (GFP), a red fluorescent protein (RFP), a near-infrared fluorescent protein, or a blue fluorescent protein (BFP).~~

~~6.~~4. The method according to ~~claim 4~~claim 3, wherein said another constituent of the biopolymer composition is a gelatin protein, and the enzyme employed in (b) includes a transglutaminase, and the gelatin protein cross-linked in (b) to the recombinantly expressed protein forms a bulking material of the biotextile material, optionally wherein the enzyme employed in (b) includes a transglutaminase, and the recombinantly expressed protein is cross-linked to said another unit of the recombinantly expressed protein in (b), and a plurality of cross-linked units of the recombinantly expressed protein form a bulking material of the biotextile material; or

wherein said another constituent of the biopolymer composition is a cellulose protein or cellulose protein composite, and the enzyme employed in (b) includes a transglutaminase, and the cellulose protein or cellulose protein composite, cross-linked in (b) to the recombinantly expressed protein, forms a bulking material of the biotextile material.

~~7.The method according to claim 6, wherein the enzyme employed in (b) includes a transglutaminase, and the recombinantly expressed protein is cross-linked to said another unit of the recombinantly expressed protein in (b), and a plurality of cross-linked units of the recombinantly expressed protein form a bulking material of the biotextile material~~.

~~8.The method according to claim 4, wherein said another constituent of the biopolymer composition is a cellulose protein or cellulose protein composite, and the enzyme employed in (b) includes a transglutaminase, and the cellulose protein or cellulose protein composite, cross-linked in (b) to the recombinantly expressed protein, forms a bulking material of the biotextile material.~~

~~9.~~5. The method of claim 1, wherein the source protein is at least one of casein, elastin, a whey protein, or pelovaterin;

wherein a concentration of the recombinantly expressed protein in the composition is 0.1% - 0.2% per unit volume;

wherein the biopolymer composition obtained in (a) is in solution and an amount of the recombinantly expressed protein in the solution is in a range from 0.84mg/ml to 3.495 mg/ml;

wherein the recombinantly expressed protein in the biopolymer composition is lyophilized;

wherein the composition comprises at least one of a gelatin, cellulose, or polysaccharide;

optionally wherein the cellulose is methyl-cellulose or microbial nanocellulose, optionally wherein in the biopolymer composition, a ratio of the recombinantly expressed protein to the microbial nanocellulose is at least 1:1000 by mass; or

optionally wherein a concentration of the gelatin in the composition is at least 20% of the composition, optionally wherein in the composition, a ratio of the recombinantly expressed protein to the gelatin is at least 1:1000 by mass;

wherein the enzyme is a transglutaminase;

optionally wherein a concentration of the transglutaminase to which the composition is exposed is 0.01% to 15% per unit volume of the composition;

optionally wherein in the composition, a ratio of the recombinantly expressed protein to the transglutaminase is in a range from 1:1 to 300:1; or

optionally wherein the crosslinking step (b) comprises exposing the composition to a transglutaminase curing bath maintained at a temperature of 25°C or lower, optionally wherein the transglutaminase curing bath has a pH in the range of 5.6 – 8.8, and/or optionally wherein the composition is exposed to the transglutaminase curing bath for at least 15 minutes;

wherein the composition comprises a bulking agent;

optionally wherein the bulking agent is first isolated and purified into a fiber, film, or pellicle prior to enzymatic crosslinking with the recombinantly expressed protein;

and/or wherein the biotextile material is at least one of a fiber, film, or biopolymer raw material.

~~10. The method of claim 1, wherein a concentration of the recombinantly expressed protein in the composition is 0.1% – 0.2% per unit volume.~~

~~11. The method of claim 1, wherein the biopolymer composition obtained in (a) is in solution and an amount of the recombinantly expressed protein in the solution is in a range from 0.84mg/ml to 3.495 mg/ml.~~

~~12. The method of claim 1, wherein the recombinantly expressed protein in the biopolymer composition is lyophilized.~~

~~13. The method of claim 1, wherein the composition comprises at least one of a gelatin, cellulose, or polysaccharide.~~

~~14. The method of claim 13, wherein the cellulose is methyl-cellulose or microbial nanocellulose.~~

~~15. The method of claim 14, wherein in the biopolymer composition, a ratio of the recombinantly expressed protein to the microbial nanocellulose is at least 1:1000 by mass.~~

~~16. The method of claim 13, wherein a concentration of the gelatin in the composition is at least 20% of the composition.~~

~~17. The method of claim 16, wherein in the composition, a ratio of the recombinantly expressed protein to the gelatin is at least 1:1000 by mass.~~

~~18. The method of claim 1, wherein the enzyme is a transglutaminase.~~

~~19. The method of claim 18, wherein a concentration of the transglutaminase to which the composition is exposed is 0.01% to 15% per unit volume of the composition.~~

~~20. The method of claim 18, wherein in the composition, a ratio of the recombinantly expressed protein to the transglutaminase is in a range from 1:1 to 300:1.~~

~~21. The method of claim 18, wherein the crosslinking step (b) comprises exposing the composition to a transglutaminase curing bath maintained at a temperature of 25°C or lower.~~

~~22. The method of claim 21, wherein the transglutaminase curing bath has a pH in the range of 5.6 – 8.8.~~

~~23. The method of claim 21, wherein the composition is exposed to the transglutaminase curing bath for at least 15 minutes.~~

~~24. The method of claim 1, wherein the composition comprises a bulking agent.~~

~~25. The method of claim 24, wherein the bulking agent is first isolated and purified into a fiber, film, or pellicle prior to enzymatic crosslinking with the recombinantly expressed protein.~~

~~26. The method of claim 1, wherein the biotextile material is at least one of a fiber, film, or biopolymer raw material.~~

~~27.~~6. The method of claim 1, further comprising:

extruding fiber by using the crosslinked composition.

~~28.~~7. The method of ~~claim 27~~claim 6, wherein the fiber is extruded at rate of 1.75 – 2.0 ml per minute, and/or wherein constant tension is applied to the fiber during extrusion.

~~29. The method of claim 27, wherein constant tension is applied to the fiber during extrusion.~~

~~30.~~8. The method of ~~claim 27~~claim 6, further comprising:

electrospinning fiber by using the crosslinked composition.

~~31.~~9. The method of claim 1, further comprising:

casting the crosslinked composition into a film, gel, or pellet suitable for textile production.

~~32.~~10. A product formed from the biotextile material generated by the method of ~~any one of claims 1-31~~claim 1.

~~33.~~11. A biotextile material comprising: (i) a recombinantly expressed protein expressed from a DNA coding sequence of a source protein, the DNA coding sequence having been optionally modified to include at least one tag sequence that enhances the crosslinking capacity of the recombinantly expressed protein; and (ii) another protein or another unit of the recombinantly expressed protein, crosslinked to said recombinantly expressed protein, the biotextile material exhibiting a functional characteristic associated with the recombinantly expressed protein.

~~34.~~12. The biotextile material according to ~~claim 33~~claim 11, wherein the biotextile material includes a plurality of fibers, and the tag sequence added to the modified DNA coding sequence for the recombinantly expressed protein enhanced fiber formation,

wherein the biotextile material includes a plurality of films formed from the crosslinked composition, and the tag added to the modified DNA coding sequence for the recombinantly expressed protein enhanced film formation;

wherein the source protein is a fluorescent protein, and both the recombinantly expressed protein and the biotextile material each has at least a fluorescence property of the source protein;

wherein the source protein is a green fluorescent protein (GFP), a red fluorescent protein (RFP), a near-infrared fluorescent protein, or a blue fluorescent protein (BFP);

wherein the recombinantly expressed protein is cross-linked to a gelatin protein forming a bulking material of the biotextile material;

wherein the recombinantly expressed protein is cross-linked to said another unit of the recombinantly expressed protein, and a plurality of cross-linked units of the recombinantly expressed protein form a bulking material of the biotextile material; and/or

wherein the recombinantly expressed protein is cross-linked to a cellulose protein or cellulose protein composite, the cellulose protein or cellulose protein composite forming a bulking material of the biotextile material.

~~35. The biotextile material according to claim 33, wherein the biotextile material includes a plurality of films formed from the crosslinked composition, and the tag added to the modified DNA coding sequence for the recombinantly expressed protein enhanced film formation.~~

~~36. The biotextile material according to claim 33, wherein the source protein is a fluorescent protein, and both the recombinantly expressed protein and the biotextile material each has at least a fluorescence property of the source protein.~~

~~37. The biotextile material according to claim 33, wherein the source protein is a green fluorescent protein (GFP), a red fluorescent protein (RFP), a near-infrared fluorescent protein, or a blue fluorescent protein (BFP).~~

~~38. The biotextile material according to claim 33, wherein the recombinantly expressed protein is cross-linked to a gelatin protein forming a bulking material of the biotextile material.~~

~~39. The biotextile material according to claim 33, wherein the recombinantly expressed protein is cross-linked to said another unit of the recombinantly expressed protein, and a plurality of cross-linked units of the recombinantly expressed protein form a bulking material of the biotextile material.~~

~~40. The biotextile material according to claim 33, wherein the recombinantly expressed protein is cross-linked to a cellulose protein or cellulose protein composite, the cellulose protein or cellulose protein composite forming a bulking material of the biotextile material.~~

~~41.~~13. A method for generating a biotextile material comprising:

(a) obtaining a biopolymer composition comprising a purified source protein;

(b) crosslinking a molecule of the purified source protein to at least another molecule of the purified source protein or another constituent of the biopolymer composition; and

(c) generating a biotextile material based on the crosslinked composition, the biotextile material exhibiting a functional characteristic associated with the purified source protein.

~~42.~~14. The method of ~~claim 41~~claim 13, wherein the source protein is a recombinantly expressed protein, and the recombinantly expressed protein is expressed from a DNA coding sequence of the source protein.

~~43.~~15. The method of ~~claim 42~~claim 14, further comprising modifying the DNA coding sequence of the source protein to include at least one tag sequence that enhances a crosslinking capacity of the recombinantly expressed protein.

~~44.~~16. The method of ~~claim 41~~claim 13, wherein the crosslinking is performed in (b) by exposing the composition to a crosslinking enzyme and/or a solution comprising calcium chloride; wherein the source protein is at least one of casein, elastin, pelovaterin, a whey protein, or a fluorescent protein;

wherein the biopolymer composition obtained in (a) comprises at least one of a gelatin, cellulose, polysaccharide, protein-polysaccharide blend, soy protein isolate, or a primary globular subunit of soy protein isolate;

wherein the biopolymer composition obtained in (a) comprises a bulking agent; and/or

wherein the biopolymer composition is obtained in (a) in a solution having a pH between 3 and 10.

~~45.~~17. The method of ~~claim 44~~claim 16, wherein the crosslinking enzyme is transglutaminase.

~~46. The method of claim 41, wherein the source protein is at least one of casein, elastin, pelovaterin, a whey protein, or a fluorescent protein.~~

~~47. The method of claim 41, wherein the biopolymer composition obtained in (a) comprises at least one of a gelatin, cellulose, polysaccharide, protein-polysaccharide blend, soy protein isolate, or a primary globular subunit of soy protein isolate.~~

~~48. The method of claim 41, wherein the biopolymer composition obtained in (a) comprises a bulking agent.~~

~~49. The method of claim 41, wherein the biopolymer composition is obtained in (a) in a solution having a pH between 3 and 10.~~

~~50.~~18. The method of ~~claim 41~~claim 13, further comprising exposing the biopolymer composition obtained in (a) to a glycerol solution, wherein a concentration of glycerol in the solution is 0.1% to 10% v/v.

~~51.~~19. The method of ~~claim 41~~claim 13, further comprising exposing the biopolymer composition obtained in (a) to a glycerol solution,

wherein the biopolymer composition obtained in (a) comprises a soy protein isolate, and wherein the crosslinking is performed in (b) by exposing the composition to transglutaminase.

~~52.~~20. A product formed from the biotextile material generated by the method of ~~any one of claims 41-51~~claim 13.